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CURRENT ACTIVITIES

ATLANTIC PROVINCES

Predator Introductions for Balsam Woolly Aphid Control.—An outline of this project was previously published in this Report (Vol. 10, No. 6, Nov.-Dec. 1954). Since this time predator introductions and a continuing study of their establishment and effectiveness have been carried on.

Since 1951 a total of 17 predacious species have been introduced from Europe (8), India and Pakistan (7), Japan (1), and Australia (1). Thirteen of the species are beetles (Coleoptera) and four are flies (Diptera). Eight species were introduced for the first time in 1959 and no information is available concerning their ability to survive and spread in Eastern Canada. The following notes deal with the present status of the remaining nine species.

Laricobius erichsonii Rosen. (Coleoptera)

Over 43,000 adults have been released in 22 locations in the Atlantic Provinces. In the vicinity of Fredericton, N. B., where most of the detailed studies on this project have been undertaken, the beetle has become well established and has shown the ability to spread slowly. Adults and larvae have been found on all degrees of infestation except the very lightest, and the larvae, feeding on the spring prey generation, have shown the ability to eliminate the infestation almost completely on individual trees. This species has shown the best control potentialities and it is planned to make small, widespread releases over the entire range of the prey in Eastern Canada as material is made available from Europe.

Pullus imperus (Muls.) (Coleoptera)

Since 1951 over 59,000 adults of this species have been released in 28 locations in the Atlantic Provinces. Although it is now considered to be established in both New Brunswick and Newfoundland, it has not shown the ability to increase or spread as was the case with *L. erichsonii*. Unlike *erichsonii*, which overwinters in the soil, this species passes the winter as an egg on the bark. In Europe studies have shown that it is apparently unable to survive temperatures lower than -15°C . (5°F .) which is considerably higher than the mean low for central and southern New Brunswick or Newfoundland. This inability to survive our winter conditions is now considered to be the main reason for its lack of success in Canada. The few which do manage to survive are probably those on the lower portions of the trunk and protected by snow cover.

Aphidecta oblitterata L. (Coleoptera)

Although this species was never released in large numbers at any one time or at any individual release area, nearly 5,700 adults have been liberated at 11 separate points throughout New Brunswick and Newfoundland since 1941. In most cases the species managed to complete one generation in the year of release but no recoveries have been made in the year following release. Collections in Europe have ranged from continental areas to more maritime regions and as they have been liberated in Canada at both inland and coastal areas, it would appear that the species has been given every opportunity to become established and that it is incapable of surviving our winter conditions.

Cremifania nigrocellulata Cz. (Diptera)

Since 1952, over 5,200 adults have been released in eight locations in New Brunswick. Two hundred were released in Newfoundland in 1959. It is now considered established in most of the release areas. Although it has been recovered in limited numbers in all release areas each year, and has managed to spread rather extensively, it has not shown the ability to increase or to provide the degree of control anticipated. The inability to increase is probably due in part to its habit of wintering primarily on the bark, but in some cases in the soil. A large number of those wintering on the bark are probably killed by our severe winter conditions, leaving only those individuals in the soil to propagate in the spring. The lack of effective control has been shown to be due also to the poor synchronization of its life cycle to that

of *Adelges piceae*. Like *Neoleucopis obscura* (Hal.), another introduced predator previously reported, the main feeding stages occur too late to prevent the hatching of a large percentage of prey eggs, thus failing to prevent increase in the subsequent generation. Like *N. obscura*, however, the feeding does have some effect and probably helps to prevent the extremely heavy infestations which were common prior to the introduction of both species.

Aphidoletes thompsoni Möhn. (Diptera)

Over 64,000 adults of this small fly have been released near Fredericton, N. B., beginning in 1957 (one small group was released in 1955). Approximately 29,000 were released in Newfoundland, most of them in 1959. At Fredericton survival has occurred over winter from the 1957 and 1958 liberations and small numbers have been recovered in and near release areas. While it is apparent that this species can exist in central New Brunswick, it is not yet known whether its population will increase to the point of effectiveness as an important control factor. As the species appears to have two generations per year in New Brunswick and as it feeds primarily on the eggs of the prey, it could become one of the more important biological control agents if its numbers increase.

Exochomus quadripustulatus (L.)

Over 23,000 specimens of this coccinellid were released from 1935 to 1940 and a few more in 1956. No survival has been recorded from any of the liberations.

Neocnemodon spp.

About 700 adults of at least two species of this syrphid genus were released in 1954. Apparently no survival occurred.

Adalia ronina (Lewis)

Small colonies (total less than 100) of this coccinellid have been released in 1958 and 1959 at Fredericton. Apparently progeny from the 1958 release did not survive the winter.

Scymnus pumilio Wse.

Approximately 7,000 adults of this coccinellid have been released at four locations in New Brunswick in 1958 and 1959. At Fredericton no survivors of the small (238) 1958 release were recorded in 1959.

The intensity of infestation and the rate of spread of the balsam woolly aphid have decreased in recent years, apparently as a result of the establishment of *L. erichsonii* and *N. obscura*, but species that are more effective, especially at lower densities of infestation, are needed if serious damage is to be prevented.—R. C. Clark and N. R. Brown.

QUEBEC

Incidence of Overwintering Parasites in Post-outbreak Populations of the Spruce Budworm in Gaspé.

In 1959, spruce budworm numbers were very low in the Gaspé region following the collapse of the outbreak in 1958 (Bi-Monthly Progress Report 14 (6) 1958). Studies carried out in a stand of field spruce in the vicinity of New Carlisle indicated that at the peak of the fourth instar, the population per one hundred square feet of foliage surface was 2,000, 840, and 18 for 1957, 1958, and 1959 respectively (1957-58 data by courtesy of J. M. McLeod).

In the course of studies on field spruce insects along the Bay of Chaleurs in 1959, a total of 140 spruce budworms were collected, 125 in the early larval stages, nine in the sixth larval instar and six in the pupal stage. This was obtained as a result of continued searching for all species of insect defoliators from white spruce foliage by four workers, over a period of two months. All spruce budworm material collected was reared in the field laboratory.

It was impossible to calculate aggregate parasitism from this material because of the great scarcity of pupae and late-instar larvae. However, a sufficient quantity of young larvae were collected to appraise parasitism in this stage. In the Gaspé, three species of parasites, *Apanteles fumiferanae* Vier., *Glypta fumiferanae* (Vier.), and *Horogenes cacoeciae* (Vier.) attack the early stages of the spruce budworm and overwinter

in the host. Of these the first two were amongst the more common species of parasites recovered between 1954 and 1958, while *Horogenes* was always rare (Blais, Can. Ent. in Press).

Forty-four of the 125 insects collected as early larvae in 1959 died in rearing of unknown causes; and calculations for parasitism were based on the 81 individuals that produced either adults or parasites. *Apanteles* was the only parasite recovered and the apparent parasitism by this species was considerably greater than in past years as can be seen from data in Table I.

The increased action by *Apanteles* appears to be a continuation of a trend already manifest in 1958. The complete absence of *Glypta* from the rearings in 1959 is of special significance. *Glypta* was the most common species from 1954 to 1957 and among the seven common species recovered in 1958, it was the only one that exhibited a decline.

The data from 1954 to 1958 were based on material collected from balsam fir, while in 1959, the host material was collected from white spruce. Differences in the relative abundance of the overwintering parasites between 1959 and the former years may be due, in part, to differences in the composition of the forest stands from which the material was collected. It is probable, however, that the great differences in the density of spruce budworm populations between the early years and the last two years of study had an even greater influence on the action of parasites attacking the overwintering larvae.—J. R. Blais.

TABLE I

YEARLY APPARENT PARASITISM BY *Apanteles fumiferanae* VIER. AND *Glypta fumiferanae* (VIER.) IN SPRUCE BUDWORM POPULATIONS IN THE LOWER ST. LAWRENCE-GASPE AREAS.

	1954	1955	1956	1957	1958	1959
<i>Apanteles</i>	2.8	7.8	8.1	7.3	11.7	39.3
<i>Glypta</i>	6.2	7.8	10.9	8.6	4.6	0

ONTARIO

The Susceptibility of Certain Geometrids to Crystalliferous Bacteria.—Preliminary trials using *Bacillus entomocidus* var. *entomocidus* (Heimpel and Angus), *Bacillus thuringiensis* var. *thuringiensis* (Berliner) and *Bacillus thuringiensis* var. *sotto* (Aoki and Chigasaki) against the western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst), and the oak looper, *Lambdina somnaria* (Hulst), were carried out at the Insect Pathology Research Institute, Sault Ste. Marie. Limited field trials using *B. thuringiensis* var. *thuringiensis* against the eastern hemlock looper, *Lambdina fiscellaria fiscellaria* (Guen.), were also conducted this summer in the Muskoka Lakes district.

Laboratory tests were carried out in lantern globe rearing cages with approximately 25 to 50 larvae per globe. Foliage, sprayed with suspension of spores and crystals, was placed in the test globes. Suitable controls were also set up. The spray used in laboratory experiments consisted of 2 mg. of spore-crystal material per millilitre. Larvae were observed daily for 100 to 200 hours. The results of these experiments are given in Tables I and II.

Field tests of the bacterium *B. thuringiensis* var. *thuringiensis* were carried out on Farey Island in Lake Joseph, near Parry Sound. Dr. C. Pardeau, the owner of the island, has for years offered the island as a Forest Insect Survey sample point for hemlock looper. He very kindly made his property available for our experiments and was most helpful in every way.

Mr. C. Barnes, the forest biology ranger in the district, helped extensively in the experiment and made the preliminary survey which established that the population of loopers was about 30 insects per 36 square feet of foliage.

Six trees (18 to 30 feet in height) were sprayed with a suspension (2-1/2 lb./100 gal.) of a commercial microbial insecticide in a 5% solution of Geon Latex 652 in water. Five similar trees to the windward of the sprayed area were used as a control.

Ten days later, branches, equivalent to approximately 36 square feet of foliage, were collected from each of the test and control trees. These were returned to Sault Ste. Marie where a thorough examination for dead and living insects was carried out. The results are given in Table III.

There is little doubt that the three species of loopers tested are susceptible to crystalliferous bacteria. However, the time required to kill these geometrids appears to be significantly longer (100-200 hours) than that required to kill other Lepidoptera (e.g. *Malacosoma disstria*, 48-96 hours). Nevertheless, examination of test globes in the laboratory showed a reduction in frass drop within 24 hours, and after several days, it was apparent that the infected insects did not feed 24 hours after ingesting spores and crystals of the

crystalliferous spore formers. In the field, the treatment caused an appreciable reduction (80 to 90 per cent) of the population in ten days.

Although these tests were limited in scope, the results justify more extensive investigation. A full-scale field experiment to determine the efficacy of these bacteria against the hemlock looper is recommended.—A. M. Heimpel and T. A. Angus.

TABLE I

MORTALITY OF FOURTH- AND FIFTH-INSTAR OAK LOOPER LARVAE AT 200 HOURS AFTER INGESTING CRYSTALLIFEROUS BACTERIA.

	<i>B. thuringiensis</i> var. <i>thuringiensis</i>			<i>B. thuringiensis</i> var. <i>sotto</i>			<i>B. entomocidus</i> var. <i>entomocidus</i>		
	No. larvae tested	No. larvae dead	% larvae dead	No. larvae tested	No. larvae dead	% larvae dead	No. larvae tested	No. larvae dead	% larvae dead
I	30	27	90	30	27	90	30	27	90
II	18	16	89	15	14	93	20	17	85
III	35	32	91	60	53	88	49	49	100
IV	13	13	100	28	24	85	15	15	100

Controls 100 larvae—no deaths, all healthy and feeding at termination of experiment.

TABLE II

MORTALITY OF FOURTH AND FIFTH INSTAR WESTERN HEMLOCK LOOPER LARVAE AT 120 HOURS AFTER INGESTION OF CRYSTALLIFEROUS BACTERIA

Bacteria								
<i>B. thuringiensis</i> var. <i>thuringiensis</i>			<i>B. thuringiensis</i> var. <i>sotto</i>			<i>B. entomocidus</i> var. <i>entomocidus</i>		
No. larvae tested	No. larvae dead	% larvae dead	No. larvae tested	No. larvae dead	% larvae dead	No. larvae tested	No. larvae dead	% larvae dead
25	25	100	30	30	100	40	38	95
						39	26	67*
						35	33	90

Controls 75 larvae—no deaths, all healthy and feeding at termination of experiment.

*This test was terminated at only 68 hours after first feeding.

TABLE III

PREVALENCE OF EASTERN HEMLOCK LOOPER LARVAE ON *B. thuringiensis* SPRAYED AND CONTROL TREES.

<i>B. thuringiensis</i> sprayed.	Number of larvae alive.	Number of dead larvae retained on foliage.
1	1	2
2	4	7
3	2	2
4	1	3
5	1	1
6	1	3
—	10	18
Totals	—	—
Control		
1	17	0
2	31	0
3	19	0
4	35	0
5	16	0
—	118	0

Some Effects of Early Fall Frost on Hardwood Vegetation.—Minimum temperatures of 28°, 22°, and 28°F. were recorded in a Stephenson-type weather shelter at the Dorset Ranger School for the nights of the 15th, 16th, and 18th of September, 1959. These represented the first subfreezing temperatures of the season and no further frost occurred for more than three weeks. (Records courtesy of William Small, Dorset Ranger School). The temperature pattern for the period in question was very similar at Chalk River. (Courtesy of James Fraser, Petawawa Experiment Station). An observer for the Dominion Department of Transport recorded a low of 26°F. at Simcoe at 8 a.m. on the morning of the 17th of September. Although different localities experienced different minima, it is clear that freezing was general in central and southwestern Ontario around that date.

During the following week it was noticed that at several locations near Dorset and Minden numerous hard maples (*Acer saccharum* Marsh.) of all sizes had many dried, curled leaves in the peripheries of their crowns. Similarly affected trees were very common between Eganville and Denbigh and the phenomenon was apparent nearly everywhere hard maple occurred in areas visited in late September and the first week of October. (Minden, Bancroft, Combermere, Denbigh, Pembroke, Algonquin Park, Huntville, Rye, and areas north and northeast of North Bay). Affected leaves had become brown and appeared seared while the unaffected leaves, in the interiors and lower portions of affected crowns,

retained their earlier colour and appearance. This was equally true for the green leaves and for the few branches or trees on which the leaves had previously assumed premature autumn colours. Although this searing of peripheral leaves was most striking in hard maple, it was present also in most other broad-leaved species in the same or similar localities. Most other tree species suffered lighter attacks. In the birches and aspens, for example, dry, dead leaves usually were confined to those shoots projecting above the general crowns.

There was practically no coincidence between areas in which trees had been affected by an August drought in the vicinity of the Dorset Ranger School and areas affected by the September frost. Neither was there any similarity of symptoms caused by the two phenomena. The drought resulted in destruction of chlorophyll and brought about yellowing of lower leaves in trees mainly on very shallow soils on hilltops and upper slopes. The frost killed leaf tissues and brought about immediate browning of upper leaves in trees, often on deeper soils and usually on lower slopes. Such affected slopes were adjacent to road-cuts or other artificial openings. Extensive leaf-searing usually did not extend more than 100 yards from the openings. The nature and extent of tissue damage to the buds or twigs associated with affected leaves will not be determined until the spring of 1960. Perhaps none will be found. However, Malcolm McLean and Harvey Anderson, Provincial Research Foresters for the South Central region, recently have shown the writers a number of specimens of branches from released or open-grown hard maples on which the terminal buds of certain leaders had failed to open one, two, or three years previously. In each instance dominance had been taken over by one or both shoots from a pair of lateral buds. Whatever had killed or otherwise prevented the breaking of the buds, usually had affected them between the apparent completion of their development and their normal time of opening next spring. It does not seem unreasonable to assume that the mid-September frost might have caused tip killing. It occurred briefly between periods of mild to very warm weather and might have caught the buds before they had properly hardened off. If this assumption proves correct, early fall frost can then be accepted as a mechanism causing at least part of the sporadic occurrence of small dead terminal shoots. These are not common every year but have been observed on most deciduous tree species essentially throughout the northern part of the tolerant hardwood region of Ontario during the past several years.

Regardless of the mechanism, however, dying of terminal shoots does occur from time to time. Many such shoots are then subjected to attacks by insects and fungi. The extent and rate at which deterioration might progress from such points of entry would depend upon the nature of those organisms, but might depend to an even greater extent on the vigour of the individual tree. This may be an important factor in the dieback of hard maple which has occurred in recent years, and probably has contributed also to the deterioration of white and yellow birch.—F. L. Raymond and A. W. Hill.

BRITISH COLUMBIA

Individual Differences in Larvae and Egg Masses of the Western Tent Caterpillar.—The original report on the effects of individual differences on the population dynamics of the western tent caterpillar, *Malacosoma pluviale* (Dyar), included a method for identifying different kinds of larvae soon after eclosion (Wellington, W. G. 1957. Can. J. Zool. 35: 293-323). The method involved exposure of the young larvae to a gradient of light on a flat surface, and observation of the amount of directed movement they exhibited while isolated from their companions.

Two types of larvae were recognized in 1956. Type I larvae were capable of independent, directed movement along the gradient, even when they were isolated from other members of their colony. Type II larvae were incapable of such movements, but even in 1956 it was clear that larvae of this type could be subdivided into at least three sub-types by differences in orientation and the amount of total activity they displayed during the test. Some were incapable of independent orientation while isolated, but responded effectively as soon as another larva was placed alongside them to reduce the amplitude of their lateral body movements. Others could travel only by following a directed larva or the silk trail it deposited. A residual group was so sluggish that its individuals seldom did more than move their heads while isolated, and did not move very far even when in contact with more active larvae. Since 1957, these three kinds have been distinguished regularly in the annual surveys, being designated Types IIa, IIb, and IIc, respectively.

Several checks of the validity of the original typing can be applied at different stages during subsequent development,

but one of the more interesting group checks developed during 1957 is applicable immediately after the initial classification has been completed. After the larvae are classified, pure groups of each type are weighed on a dial torsion balance. Because the larvae are so small, groups of 40 are most convenient for survey purposes. Table I shows the mean weights of the four types of larvae. Each differs significantly from the others, implying that physical, as well as physiological differences exist as early as the eclosion period.

These physical and physiological differences are most apparent between Types I and IIc larvae. The former are not only more active but also larger and plumper than the latter, which often have a shrivelled appearance, so that their heads seem wider than their bodies. In fact, many Type IIc larvae die soon after eclosion, and few reach maturity in the laboratory or the field. Some are incapable of freeing themselves completely from their eggs, and there is reason to believe that many unhatched eggs are, in fact simply IIc individuals too weak to emerge. When unhatched eggs are considered in this manner, some interesting associations between the original condition of the egg masses and the final proportions of the IIc components are revealed (Table II).

Egg masses of *M. pluviale*, like those of *M. disstria*, are covered by a layer of frothy spumaline that protects them from desiccation and from some kinds of predation and parasitism. If eggs are collected during the autumn, no great difference in spumaline condition or coverage is apparent, but if they are allowed to overwinter where the moths deposited them, they show major variations in spumaline response to erosion by rain, frost, and temperature changes. Spumaline that was originally thin, with few layers of bubbles, is soon eroded completely or reduced to a varnish-like layer. Thicker kinds containing more layers of larger bubbles seldom erode completely in comparable exposures, and always retain their original spongy texture. These changes result in differences in final coverage, so that some egg masses collected in late February consist entirely of exposed eggs, whereas others have only small bare patches, and still others remain completely covered. Apparently, different kinds of females deposit different amounts and kinds of spumaline on their egg masses, and winter erosion ultimately reveals this variability.

Whether winter climate also contributes during the erosion process to the ultimate differences in the proportions of emerging larvae shown in Table II is a subject for future research. The appearance of many IIc larvae strongly suggests that they have utilized all their food reserves before emerging, whereas Type I individuals clearly have some reserves. Exceptionally mild winters that retain larvae near their developmental thresholds may well contribute to an existing IIc component by downgrading many IIb larvae to the IIc state, and relegating weaker IIc larvae to the "unhatched egg" category. In any event this approach to the problem of the effects of winter climate on tent caterpillar survival seems more promising than the usual method of exposing autumn-collected egg masses to artificial cold indoors.

Although all types of larvae are important in colonial life after eclosion, the proportions of Types I and IIc are of special interest, since they often determine the fate of colonies and even of infestations. For example, a colony that contains few I's and many IIc's rarely produces any adults, even when it is very large and located in the most favourable environment. Consequently, if there are many such colonies in an area, the local population will collapse in the absence of immigrants from other areas.

Precise information on the relative numbers of the two types, therefore, is worth obtaining at the beginning of seasonal development. Nevertheless, when large quantities of material must be handled, even the simple method of separation used in this work becomes too laborious. A skilled observer can classify more than 600 larvae per day, as well as care for them after their establishment on food, but when seasonal totals surpass 17,000, some sort of sampling method must replace the more desirable total counts used in earlier work.

Table III describes the regression equations obtained from 1957 data and used in subsequent years. They were derived because the proportions of Types I and IIc larvae emerging during the first two days of an eclosion period did not seem to differ much from the final proportions obtained after eclosion was complete. Since the mean laboratory eclosion period/egg mass in 1957 was 4.04 ± 0.15 days at 21°C ., and stragglers often appeared after six days, employment of the equations has saved considerable time. The only other items of information necessary to describe a colony adequately enough for survey purposes are total eggs and total hatch. For special purposes, other information, such as numbers of unhatched, parasitized, and chewed

eggs, is desirable, together with the numbers of Types IIa and IIb larvae that emerge.—W. G. Wellington.

TABLE I
MEAN WEIGHTS OF THE FOUR TYPES OF *M. pluviale* LARVAE WEIGHED
IN GROUPS OF FORTY IMMEDIATELY AFTER ECLOSION: 1957

	Larval Type			
	I	IIa	IIb	IIc
\bar{x} (mg/group).....	11.72**	11.18**	10.83**	10.06**
s _x	0.04	0.02	0.02	0.04
n (groups).....	24	26	80	36

**P<0.01 for all mean differences.

TABLE II
THE PROPORTIONS OF DIFFERENT LARVAL TYPES EMERGING FROM AN EGG MASS
RELATED TO THE AMOUNT OF SPUMALINE ON ITS SURFACE AFTER WINTER EROSION:
1957

	Percentage of egg mass surface covered by spumaline		
	>95	80-95	<80
% Type I larvae*.....	14.44 ± 2.00	9.49 ± 1.56	8.74 ± 1.91
% Type IIc larvae + unhatched eggs*.....	18.49 ± 1.93 ^{b,c}	29.13 ± 2.49 ^b	36.55 ± 4.33 ^a
n (egg masses).....	20	21	15

*Percentages of eggs available for hatching; i.e., those not chewed or parasitized.

^{b,c} P<0.05 for these mean differences.

TABLE III
REGRESSIONS OF THE PERCENTAGES OF TYPES I AND IIc LARVAE EMERGING FROM
EGG MASSES DURING THE FIRST DAYS ON THE PERCENTAGES ACCUMULATED
DURING THE WHOLE ECLOSION PERIOD: 1957

	Larval Type	
	I	IIc
\bar{x}	12.04	20.23
\bar{y}	12.39	22.27
b.....	1.2395***	0.9745***
sy.x.....	4.81	8.82
r.....	0.91***	0.79***
Y _e	1.2395X - 2.53	0.9745X + 2.55
ranges of X over which the regressions were calculated.....	0.75-30.42%	6.52-54.98%
n (egg masses).....	56	56

***P. <0.001

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